INVESTIGATION OF CLOUD PROPERTIES AND ATMOSPHERIC PROFILES WITH MODIS

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ABSTRACT

The WINter Cloud Experiment (WINCE) was directed and supported by personnel from the University of Wisconsin in January and February. Data sets of good quality were collected by the MODIS Airborne Simulator (MAS) and other instruments on the NASA ER2; they will be used to develop and validate cloud detection and cloud property retrievals over winter scenes (especially over snow). Software development focused on utilities needed for all of the UW product executables; preparations for Version 2 software deliveries were almost completed. A significant effort was made, in cooperation with SBRS and MCST, in characterizing and understanding MODIS PFM thermal infrared performance; crosstalk in the longwave infrared channels continues to get considerable attention.

TASK OBJECTIVES

Software Development

The five UW science production software packages (cloud mask, cloud top properties, cloud phase, atmospheric profiles, and ancillary data) continue to evolve. Science algorithms are being tested with MAS data from both the SUCCESS and WINCE experiments. Visualization tools to view data and products efficiently continue to be developed. Common utilities needed for processing in the DAAC environment are being finalized for use with all science production software packages.

MODIS Infrared Calibration

UW is working closely with SBRS and MCST in evaluating the MODIS thermal infrared calibration data from the thermal vacuum test. Paul Menzel, Dan LaPorte and Chris Moeller participated in the MODIS Thermal Infrared Calibration Team Meeting in January at the University of Miami. UW has been analyzing SBRS characterization of the infrared spectral response functions and longwave infrared crosstalk. Dan LaPorte worked with the MODIS engineering team during the thermal vacuum calibration of the PFM and is coordinating data set transfers to MCST and UW.

WORK ACCOMPLISHED

MODIS Infrared Calibration

The MODIS Thermal Infrared Calibration Team met at the University of Miami on 9-10 January 1997. MODIS instrument performance, delivery and testing schedules were discussed. Inspection of characterization data of the MODIS system relative spectral response (RSR) functions for the longwave infrared (LWIR) revealed a 5 nm shift to longer wavelengths, based on spectral position comparisons between the RSR and forward model data. Chris Moeller presented simulations with MAS data showing that the expected crosstalk has significant effect on brightness temperatures that must be corrected. It appears likely that ground corrections to radiances will be necessary for the MODIS on the am platform, but it is hoped that an instrument fix can be arranged for the MODIS on the PM platform. It was stressed that corrections not possible for the PFM should be considered for the FM1, schedule and cost permitting. Paul Menzel presented results showing successful application of the MODIS calibration algorithm to GOES data; the MODIS correctly characterizes the detector voltage as a quadratic function of the incoming radiance (GOES has radiance as a quadratic of detector voltage). The team concurred that considerable progress had been made in the last three months toward characterizing MODIS PFM infrared performance, understanding the best approaches toward ground processing of radiances, and suggesting instrument changes to ameliorate problems on FM1. However some infrared bands remain problematic and more needs to be done. Several action items were assigned to UW: (1) UW will work with SBRS and MCST to determine the best RSR for the PC infrared spectral bands (31 through 36 are likely to have a 5 nm shift). Band 34 RSR seems out of family and is still puzzling. (2) UW will generate tables using FASCODE to correct for water vapor absorption in the LWIR and MWIR for various configurations of the vacuum test. These have since been delivered to SBRS for on site assistance in interpreting PV RSR test results. Possible spectral shifts in bands with sufficient absorption features (24, 25, 26, 27, 28, and 30) will be estimated by comparing calculated and measured spectra. (3) UW will study the current gain settings for the infrared bands to assure that truncation error is less than NEDR. (4) UW will suggest to NOAA that in order to minimize complications caused by the scan mirror emissivity, a subset of the data near the onboard blackbody angle should be considered. UW has suggested that NOAA consider data at -45 to - 5 degrees from nadir.

As guidance for assessing SpMA spectral position accuracy of all PC band RSR ambient data (collected in Dec. 1996), Chris Moeller assessed the spectral position accuracy for all channels of band 35. Because of the shape of the SpMA image on the MODIS focal plane, it is expected that spectral position accuracy of the RSR data is a function of channel number (i.e. position on the focal plane). The analysis matches the spectral position and shape of the 13.88 micron Q branch CO_2 absorption feature in the measured RSR data with that from LBLRTM (Line-By-Line-Radiative-Transfer-Model) forward model transmittances. Ambient laboratory conditions (temperature, humidity, CO_2 concentration, etc.) were used as input to LBLRTM. The LBLRTM transmittances were convoluted to the SpMA bandpass characteristics at a series of spectral positions given by SpMA reported spectral position plus a small spectral correction (on the order of nanometers). An example of this analysis is given in Figure 1. The assessment for all channels shows that spectral correction is a systematic function of channel number, with the exception of channel 10 which appears "out of family" (Figure 2). A separate analysis of central wavelength as a function of channel number (performed at GSFC) indicates a similar dependence although actual values do not agree. Further data analysis and discussion are required to resolve discrepancies.

Data for MODIS PV band RSR have not yielded definitive spectral correction results for those bands/channels. A special fine-spectral increment data set was collected after allowing ambient air to leak back into the beam path within the purged tent environment fronting the MODIS Calibration Chamber. The approach was to measure RSR across several spectral features in the presence of sufficient atmospheric attenuation to define those spectral features. By comparing to forward model spectral features (calculated using LBLRTM w/HITRAN96 database), a spectral correction for the PV band MODIS RSR data set can be estimated. RSR data was collected from 6750 to 6901 nm at 1 nm spacing (13 nm FWHM), covering water vapor absorption features at about 6780 and 6860 nm. Unfortunately, the special data set did not show sufficient features to make a useful spectral correction assessment. Apparently, additional atmospheric water vapor attenuation in the beam path was needed to manifest spectral features in the special data set. Another source of information for assessing spectral correction of MODIS PV band RSR is the coarse-spectral increment RSR data collected in ambient conditions. A forward model spectral correction will be attempted using that data; however, the coarse increment data set wants for better spectral resolution to define the small spectral adjustments (nanometers) expected. The coarse-spectral increment data can also be used in a central wavelength assessment of spectral correction. This approach requires an assumption of spectral uniformity from channel to channel within band (a reasonable assumption for channels 2-9 but not likely for channels 1 and 10). In all likelihood, some combination of these two approaches will be used to specify final MODIS PV band RSR spectral correction. To the extent useful, component data will also be inspected to aid the spectral correction analysis.

Dan LaPorte has been working with the engineering team to understand the nature of the PC band crosstalk (band 31 into bands 32 through 36) for PFM. Initial estimates from measurements in ambient conditions (UAID 1194x) indicate that the peak values of crosstalk (primarily east west) when viewing clear sky typical conditions are roughly 10% of band 31 leaks into bands 35 and 36, about 4% into band 34, and about 1% into bands 32 and 33. In partly cloudy conditions when band 31 views the surface and band 36 views a cloud, the crosstalk can increase the band 36 radiance output by as much as 50%. Single field of view applications of these channels will be challenged, but it's very likely that 5 x 5 km applications will be useful after correction for crosstalk. However, much remains to be done. Efforts by SBRS, MCST, and UW continue to assess crosstalk issues; a thermal calibration (RC02) data set collected in thermal vacuum is under evaluation for additional understanding and quantification of PC band crosstalk.

The benefit of the space roll to MODIS products was investigated by UW. The benefit of the correction for scan mirror effects on GOES-8/9 were documented; calibration efforts by NOAA/NESDIS (Mike Weinreb) succeeded in reducing the east west bias in radiances measured when viewing space and the improvement in GOES total water vapor retrieval was noticeable (the first guess rms error was reduced by 0.2 mm or 5% without correction and 0.8 mm with correction or 20%). Chris Moeller attended a NASA discussion of the space roll for the PM platform; he showed the impact of a scan mirror uncertainty of .02 on MODIS infrared window brightness temperatures to be greater than 0.5 C. The MODIS cloud mask also produced significantly less confident results. With a space roll that characterizes the MODIS IR calibration to within 1%, these uncertainties in MODIS derived products are largely mitigated. It was decided to roll the PM platform to space during checkout.

MODIS Validation Activities

UW submitted a flight request to the NASA Airborne Science and Applications Program for FY98. Seven ER-2 missions (30 hours) were requested. Mission objectives include (1) evaluation of the new scanning HIS and NPOES Atmospheric Sounder Testbed (NAST) instruments which will fly with MAS for validating MODIS products, (2) NOAA-K underflights, and (3) overflights of the DOE ARM site in Oklahoma in conjunction with MODIS overpasses late in FY98 for first assessment of MODIS performance. These flights will support MODIS cloud properties and atmospheric profiles and Level 1B radiance validation. The MODIS validation plan has been updated to reflect changes in near and long term validation activities, primarily related to ER-2 deployment and underflight of MODIS.

MODIS Software Development

Software development efforts lead by Kathy Strabala have focused on common utilities accessed by all UW MODIS science production software packages. Common routines to automatically create the UW MODIS output products during production, read and extract common metadata, open and extract L1B radiances and geolocation information, and write error and status messages to the correct log files have all been written and tested using SDST approved toolkits and libraries. Care has also been taken in adding diagnostic statements to all product subroutines which can be output to a runtime ascii file by setting a flag in the main program. As this common utility effort nears completion, we await final input versions to finish code development and testing.

Version 2 MODIS code has been modified so that the make files are relatively consistent for the different products. A Revision Control System (RCS) has been set up for all of the MODIS product software. The RCS directories contain an archive of all of the changes that will be made for the V2 MODIS product code. In the process, RCS ID's have been included in the V2 MODIS product code such that each executable contains information of the versions of all the subroutines used to create that executable.

A development environment for the UW Version 2 deliveries was set up on the UW SGI. V1 algorithm codes were retrieved from CM at GSFC and recompiled. All source text files were checked into RCS. The latest simulated MODIS data was obtained from GSFC and installed on modsgi (Figure 3).

Code to create the output HDF files for the MODIS products has been written. This is a multi-step process. In the first step, a C program reads in the MODIS file specs in CDL format. The C code takes the file specs and creates two FORTRAN subroutines which are called by the main program to assist in creating the output HDF files. This ensures that the output file structure will identically match the file specifications. Generic read and write routines have also been created which move data in and out of the HDF output files. Testing of the effects of the HDF compression routines on the size of the output cloud mask file is underway.

Progress has also been realized in a MODIS data set. Using IDL routines, Walter Wolf has selected MAS data that matches the MODIS channels, resampled the MAS data to the MODIS resolution (using Liam Gumley's IDL routine), and then created flat files containing MODIS simulated data. For water vapor channels (missing on MAS), a second IDL routine reads HIS water vapor channel data, matches the latitude and longitude to the MAS latitude and longitude, and creates simulated MODIS data for the associated channels. This routine also creates flat files of latitude, longitude, solar azimuth, solar zenith, sensor azimuth, and sensor zenith data. An ascii time record file is also created.

Considerable effort was expended in providing MAS quicklook capability for the WINCE experiment. Software originally developed for SUCCESS was modified, updated, and documented to run on the NASA Ames Sun workstation. This software was successfully installed and tested on the Sun, and was used during WINCE by UW and NASA personnel to generate MAS quicklook imagery within 24 hours of ER-2 landing. NASA Ames will now use this software routinely to produce MAS quicklook imagery in the field.

Visualization Software

Two MAS visualization tools were released via the Web to GSFC and ARC.

(a) MASVIEW: http://cimss.ssec.wisc.edu/~gumley/masview/masview.html
MASVIEW displays single bands of full resolution MAS imagery read from any of the following formats (which are identified automatically):

- Exabyte raw format as recorded onboard the aircraft (57344 bytes per block),
- University of Wisconsin Intermediate format created by readtape5.f (74200 bytes per block),
- NASA/GSFC HDF Level 1B format.

Some of the options available in MASVIEW include:
- Display data as counts, radiance (HDF only for bands 1-25), or brightness temperature,
- B&W or Color Postscript output (user can customize size and orientation),
- Can easily flip between any number of images (movies!),
- IR bands can have a reversed grey scale color table so clouds are bright and land is dark,
- If HIS data is available, plot HIS FOV locations on MAS image,
- Save image as GIF,
- Display subsets (e.g. scan 1-1500) of large HDF scenes,
- Skip every other scanline to compress images vertically.

(b) DISPLAYQUICK:
http://cimss.ssec.wisc.edu/~gumley/displayquick/displayquick.html
DISPLAYQUICK displays MAS subsampled quicklook data in a scrolling image window, allowing a user to view an entire flight of data. HIS spectrum locations may be plotted on top of the imagery, and by clicking on the image with the mouse, the nearest HIS spectrum will be plotted. This tool was used for interactive demonstrations (on a laptop) at the AIRS Science Team meeting and the AIRS ATBD reviews.

A new visualization tool for MODIS Airborne Simulator data was demonstrated at the MODIS Science Team meeting in May. This tool incorporated many of the features of SIVIS (http://mistral.larc.nasa.gov/~vasanth), but was written in IDL to provide portability. This program was designed from the start to be easy-to-use; to provide a set of features appropriate to cloud mask algorithm development, and to provide publication quality graphics output. This program was demonstrated on an IBM Unix laptop to the MODIS Atmosphere Group.

A newer version of this program has recently been developed and released within CIMSS for testing. It reads GSFC produced MAS HDF files directly, and runs on any PC or workstation (with IDL installed). It has a simple interface (Figure 4) which offers a set of features appropriate to the MODIS Atmosphere Group. GIF and Postscript file output is as simple as clicking on the 'GIF' and 'PS' buttons at top right. This program has already run on SGI, Sun, IBM, Linux, and Windows NT platforms (it should also work on Power Macs). New features to be added are RGB image combinations, identification of band wavelengths, and fusion of HIS data. CIMSS intends to develop a similar visualization program for MODIS.

HIRS Cloud Climatology

The HIRS CO2 cloud climatology now contains eight boreal winter (December - February) and eight boreal summer (June - August) seasons from June 1989 to May 1996. Cloud occurrence, height, and effective emissivity are determined with the CO_2 slicing technique that accounts for clouds partially filling the sensor field of view and semi-transparency of some clouds. More than 40% of the HIRS observations find cirrus clouds; their presence appears to be gradually increasing about one percent per year. This unprecedented high detection of cirrus clouds is supported by recent aircraft experiments during SUCCESS that found nearly continual presence of nearly invisible layers of small ice crystals mostly transparent near 10 microns but highly absorbing toward 12 microns. Comparisons with cloud studies conducted by ISCCP reveal similar trends from year to year, but the ISCCP cirrus detection is less than half that of HIRS. Comparisons with SAGE high cloud frequency distributions are quite good; global patterns are well correlated. A paper on this work was presented at the ninth International TOVS Study Conference held in Igls, Austria 20 - 26 February 1997 and will be part of the technical proceedings of that conference (Menzel et al., 1997).

Adjustments to the global statistics have been necessary. Results from before May 1991 were processed with clear sky radiances inferred from non nadir (out to 25 degrees from nadir) observations of HIRS. Results after May 1991 used only near nadir radiances (out to 10 degrees from nadir). Cloud properties were calculated only for near nadir observations throughout this study (before and after May 1991), but the difference in clear sky radiance fields has required an adjustment to the cloud statistics. This has eliminated the noticeable increase in cirrus cloud cover that occurred at May 1991; prior to May 1991 cirrus cloud detection has been reduced by 5.6%, opaque clouds increased by 6.4%, resulting in clear sky reduction by 0.8%.

Cloud Mask

The AVHRR and MAS cloud mask algorithm have evolved in several areas:

(a) Testing of prototype clear-sky brightness temperature maps was completed using AVHRR Global Area Coverage data from the Atlantic Ocean. Single-pixel, high quality (confidence of unobstructed surface > 95%) clear-sky values of 11 μm brightness temperature were obtained by the AVHRR cloud masking algorithm in ocean regions during daylight hours. These values were incorporated into an eight-day composite equal-area grid at 25 km resolution. The composite file was updated after each day was processed, that is; the clear-sky observations from day one of the previous eight days was eliminated and those from the day just processed were added. Mean, minimum and maximum brightness temperatures were made available to the nighttime algorithm to be used as additional input to the cloud mask. The additional information was found to aid in detection of low-level clouds at night, particularly in the eastern South Atlantic where stratus clouds are very common. A total of 16 days were processed.

(b) A new land/sea tag file was obtained and implemented in the AVHRR and MAS cloud mask algorithms. The file contains seven categories of surfaces: land, coast, intermittent water, shallow inland water, deep inland water, shallow ocean, and deep ocean. The additional information is useful for identifying discontinuities on the surface which may have an adverse effect on the cloud mask output, such as ocean and lake shorelines and river deltas.

(c) A surface snow-detection algorithm provided by Brian Baum of Langley Research Center has been implemented in the AVHRR cloud mask. Even though the AVHRR has a limited number of channels for this task, the method has made great improvements in polar, daytime cloud discrimination.

(d) In response to favorable results from tests in the AVHRR cloud mask algorithm, several changes have been made to the MAS cloud mask code. A new land/sea tag file has been implemented which contains more information than the previous version. New routines for use in coastal regions have been added. These employ the concept of a coastal “zone”, rather than a strict land/water separation, and use threshold tests appropriate for land surfaces. Although some errors still occur (sometimes due to imperfect navigation), results are improved over the earlier method. A number of ecosystem types have been identified where the visible ratio test (ratio of channel 7 and channel 2 reflectances) is not appropriate to use. These are mostly desert and semi-arid regions. The “wetland” flag has been replaced with a “desert” flag as it reflects a different path through the cloud mask algorithm. The “polar daytime” processing path has been eliminated from the code. Instead, the program will automatically determine whether or not snow or ice is present and apply the appropriate threshold tests. A land shadow detection algorithm has been added along with a routine to identify thick smoke.

(e) Routine cloud masking of AVHRR Global Area Coverage (GAC) data has begun. Three orbits of data covering roughly the same areas of the earth are processed each day. The areas include major deserts (Saudi Arabian Peninsula), tropical rain forests (Amazon), and mid-latitudes (central North America). The intent is to monitor seasonal changes in radiance data as applied to cloud mask threshold tests and to identify those regions where cloud detection thresholds vary appreciably with season. Variations in surface and air temperatures, crop production and harvesting, and biomass burning are only a few items which could change expected radiance values and have adverse effects on the output cloud mask.

In April, Steve Ackerman visited Goddard and discussed the cloud masking approach with MODIS scientists. There are several groups making use of the UW cloud mask algorithm that operates on the MAS HDF files. Several scientists have used this algorithm on their experimental data sets. This approach has lead to improvements of the cloud mask and represents a frame work for post launch validation activities.

Improvement on detecting heavy-aerosol loading continued during this quarter using SCAR-B data. This remains a difficult problem and one that we will continue to work on during the next quarter.

The latest version of the cloud mask algorithm that operates on the MAS HDF files is now available. This includes some cloud detection improvements based on work conducted here at UW and by investigators at GSFC.

Steve Ackerman attended the GLI meeting in Japan as a representative of the MODIS atmosphere group. He presented an approach of adapting the MODIS cloud mask to the GLI approach. The GLI team accepted this approach. The GLI mask will be a 16 bit mask, similar in character to the first 16 bits of the MODIS mask. Final details about the GLI cloud mask structure will be worked out this quarter.

AVHRR LAC data is used in the development of the MODIS and MISR cloud mask algorithms. Through discussions with Drs. Clothiaux and Di Girolamo of the MISR team, we have identified a data set and an approach of how to compare the MODIS and MISR cloud masking procedures prior to the launch of MODIS. This comparison began this quarter and will continue, and hopefully be completed, in the next quarter.

GOES Biomass Burning Program

The following work is being funded under separate NASA (NAGW-3804) and NOAA contracts, but is included in this report as it is relevant to MODIS fire detection activities. .

(a) Daily multispectral GOES-8 imagery (at 1145 UTC) collected during the SCAR-B field program in South America (15 Aug.-15 Sept., 1995) were processed with an updated version of the GOES-8 Automated Smoke/Aerosol Detection Algorithm (ASADA, version 2.0). The algorithm uses single and multiband difference thresholds (including visible, 4, 11, and 12 micron data), solar zenith angle corrected albedo calculations, and solar and satellite viewing geometry in the process of distinguishing smoke/haze from multi-level clouds, low-level moisture, and sun glint. The revised algorithm shows significant improvements in identifying sun glint contamination and in locating smoke in northwestern Brazil where it is often difficult to separate smoke from low-level moisture in the Amazon. Version 2.0 also includes a test to check for clouds in nearest neighbor pixels. This test has significantly reduced false positive identification of smoke along gradients between clear and cloud contaminated pixels. An example of GOES-8 visible imagery and the GOES-8 ASADA (version 2.0) derived albedo product for 28 and 29 August are shown in Figure 5. A series of GIFs (G8A*.GIF) showing the GOES-8 ASADA derived albedo product for each day during SCAR-B is available via anonymous ftp at winds.ssec.wisc.edu. Efforts are under way in Version 2.5 of the ASADA to improve identification of smoke in areas where the background albedo is low (over water) and in areas where the smoke albedo signature is very high and often incorrectly characterized as cloudy.

The SCAR-B GOES-8 diurnal data set was reprocessed with version 2.0 of the GOES-8 ABBA. Version 2.0 contains a number of changes resulting in a more robust algorithm including a new approach to cloud clear and characterize the background brightness temperature field. The technique uses a combination of visible albedo, single band thresholds in the 4 and 11 micron infrared windows, and a 4 minus 11 micron difference histogram approach with variable thresholds based on the local solar zenith angle. This approach appears to do a better job of cloud clearing and provides an improved representation of the 4 micron background brightness temperature field. This technique has significantly reduced the occurrence of false positive fires especially within several hours of local noon in areas of enhanced solar reflectance in the 4 micron band and is better equipped to distinguish sub-pixel cloud contamination. Version 2.0 is less dependent on predetermined thresholds to account for viewing conditions and ecosystem characteristics. The GOES-8 ABBA (Version 2.0) results indicate significant improvements in identifying and processing fires under a variety of viewing conditions and in different ecosystems. Figure 6 shows an example of the diurnal GOES-8 ABBA fire product for 24 August 1995. A series of GIFs (G8F*.GIF) showing the diurnal GOES-8 ABBA fire product for each day during SCAR-B is available via anonymous ftp at winds.ssec.wisc.edu.

(b) Capabilities for early warning fire detection in North America were investigated as part of a collaborative multi-sensor (GOES, POES, DMSP) assessment study coordinated by Chris Elvidge at the National Geophysical Data Center (NGDC). Initial versions of the North American GOES ABBA have been implemented for applications in New Mexico (GOES-8) and Alaska (GOES-9). The revised GOES-8/-9 ABBA (version 2.0) was used to process half-hourly multi-spectral GOES-8 imagery collected on 9-13 June 1995 in New Mexico and half-hourly GOES-9 imagery on 24 June 1996 in Alaska. The New Mexico data set provides a good example of the capabilities and limitations of GOES fire detection in the southwestern US. The GOES-9 data collected over Alaska documented a number of fires between 60 and 70°N indicating the potential for GOES-9 fire detection and diurnal monitoring at northerly latitudes. A summary of CIMSS GOES ABBA results for New Mexico and intercomparisons with NOAA AVHRR and DMSP-OLS fire observations are presented in the NGDC draft report “Wildfire Detection with Meteorological Satellite Data: Results From New Mexico During June of 1996 Using GOES, AVHRR, and DMSP-OLS” (C. Elvidge, et al, 1997).

DATA ANALYSIS

WINCE Field Experiment

The WINter Cloud Experiment (WINCE) data collection phase was completed in February 1997. WINCE is an early effort in a series of planned ER-2 deployments in support of MODIS product development and validation in both the pre-launch and post-launch phases. WINCE was designed to study clouds, snow, and ice in the complex mixed scene (clouds over snow/ice background) conditions of winter environments in support of the algorithm development for MODIS cloud and snow products. A NASA ER-2 aircraft, the primary data collection platform, was deployed from Madison WI from 23 Jan - 13 Feb, 1997. The ER-2, carrying an instrument complement including the MODIS Airborne Simulator (MAS), High-spectral resolution Interferometer Sounder (HIS), Cloud Lidar System (CLS), Microwave Imaging Radiometer (MIR), Tilt Scan CCD Camera (TSCC), and RC-10 camera, flew 10 missions (52 hours) in the 21 day period. UW ground based measurements included the UW uplooking HSRL lidar, AERI for atmospheric profiles and constituents, downlooking radiometry of snow surfaces and snow crystal sampling, and classonde balloon launches. As much as possible, these ground based measurements were collected during every ER-2 flight. GOES, TOVS and standard NWS measurements were captured and archived for each day as well as cooperative observer networks for snowfall and depth. The WINCE data set covers many different combinations of cloud and surface conditions and captures simultaneous observations from several other observing systems; it includes thin/thick low/high cloud over snow, ice, water and bare land backgrounds, clear scenes of snow, ice and water surfaces, daytime and nighttime conditions, overpasses of ground-based measurements (snow depth, emissivity, uplooking interferometers and lidar, atmospheric chemistry, classondes), and underpasses of the polar orbiting ADEOS satellite (OCTS, IMG, and POLDER). Many data sequences include transitions from cloudy to clear scenes over uniform snow background (day and night), bare ground to snowcover, and snow to icecover to open water.

Work has begun on prioritizing science data sets for WINCE. A meeting of WINCE instrument PIs was held at GSFC in May. During the meeting discussion of data flights and instrument data quality were held. The objectives of each PI are met by a variety of ER-2 flight days during WINCE. Some level of data exchange has begun. A plan was also set forth to hold a WINCE science meeting in the Fall of FY98. Highlights of the data collection include:

Date	Flight	Highlights
1/28	97041	clear snow scenes, cirrus over snow, ADEOS underflight
1/29	97042	thin to thick cirrus transition, bare ground to snow transition
1/30	97043	repeat overpasses of water and ice cloud with UW based HSRL
2/2	97044	thin cloud over L. Superior ice, ADEOS underflight
2/6	97045	thin cloud over Hudson Bay ice and ice leads
2/8	97046	clear water over L. Huron, water to lake ice to snow transition
2/9	97047	snow scenes w/Hall ground based measurements
2/10	97048	night flight, thin to thick cirrus transition over snow background
2/12	97049	clear snow scenes over Hall site in WI, ADEOS w/TSCC
2/13	97050	thin cirrus scenes over HSRL, ADEOS underpass.

For example, data scenes over Hudson Bay show thin low cloud over the ice and snow covered bay (Figure 7). This transmissive cloud is difficult to discern in MAS visible imagery (because of bright snow/ice background) and is essentially invisible in the 11 micron window data (the imagery shows dramatic ice leads over the entire region). Strong evidence that the clouds exist is given by cloud shadows on the ice background and by CLS downlooking lidar data from the ER-2 platform. This is an example of WINCE data that will be used to severely challenge and refine the skill of the MODIS cloud mask algorithm. Cloud detection spectral tests using MAS 4 micron data will be tested on this scene. A second example (Figure 8) shows thin cirrus scenes over snow background in North Dakota. The MAS 1.88 micron channel (similar to MODIS 1.38 micron) does a good job of depicting the thin cirrus coverage. Unfortunately, the 1.38 micron data will not be useful at night. Nighttime cirrus scenes over snow and ice are however included in the WINCE data collection and will be investigated for cirrus detection.

A WINCE homepage was created at:
http://oldthunder.ssec.wisc.edu/wince/wince.html.
The homepage includes a daily quicklook archive with flight summaries, flight tracks, quicklook MAS imagery, and interesting data segments. CLS instrument quickview imagery and ground based measurements of snow depths at Madison, WI have been added to the homepage as well as tabulated summaries of data collection and objectives.

A modified MAS processing procedure has been instituted for MAS data set dissemination from the GSFC DAAC; it has been streamlined with the intent of speeding up the distribution of these data. The MAS WINCE data set represents the first test of this procedure. Three MAS data flights have been selected as "Golden" days for high priority processing with a preliminary radiometric calibration. Those days are 6 Feb (flt 97-045), 9 Feb (flt 97-047) and 12 Feb (flt 97-049). These data sets became available to WINCE participants and instrument PIs by 1 May, less than 3 months after the completion of the WINCE data collection. MAS final calibration assessment for the WINCE data set is underway. A MAS final calibration WINCE data set is planned for release in FY98.

MAS SUCCESS Data Processing

Final calibration for the MAS SUCCESS data set has been completed. Laboratory spectral measurements collected in March and June 1996 have been reviewed and corrected for the ambient conditions in the Ames calibration laboratory. Ambient laboratory atmospheric absorption was estimated using the Line-By-Line-Radiative-Transfer-Model (LBLRTM) with the HITRAN96 database. The high spectral resolution forward model output is convoluted with the monochromator characteristics to remove spectral dependencies. Using several well-defined spectral features, the monochromator spectral position reporting accuracy was assessed. This assessment was based on a comparison of absorption feature shape as given in the MAS output and the convoluted forward model data. It was observed that small spectral corrections to the monochromator reported spectral position resulted in much improved absorption feature shape matching, and removal of spectral features from the atmospherically corrected SRF. The spectral correction is a function of the diffraction grating used for the spectral measurements; spectral corrections were on the order of 1% of total spectral bandpass for MAS channels. The spectral corrections were incorporated into the final MAS calibration for the SUCCESS data sets.

The March and June 1996 atmospherically corrected SRF showed spectral position discrepancies for Ports 3 and 4 of about 30 and 70 nm respectively. In order to answer the question of how to apply this discrepancy to the MAS SUCCESS data set, the MAS and well-calibrated HIS data sets were compared for various flights during the experiment. The comparison for data early in the SUCCESS deployment on 13 April 1996 revealed that MAS-HIS biases were sharply reduced, especially for the spectrally sensitive MAS channels 34-36, 43, and 48-50 when using the June '96 SRF instead of the March '96 SRF. This is a strong indication that the June '96 SRF should be applied and the March '96 SRF ignored. Similar bias reduction was realized in comparisons of the MAS-HIS biases for other data flights during SUCCESS (April 08, April 15, May 03, May 08). The MAS SUCCESS final calibration data set is now being processed at the GSFC DAAC using the June '96 atmospherically corrected SRF.

A new MAS fast transmittance model has been generated using the final SRF for the SUCCESS data set. The model is being used in forward calculations for MODIS cloud top properties algorithms and in surface and atmospheric temperature/moisture retrievals using MAS data. The impact of spectral uncertainty on the cloud top properties has been investigated using the model. Using MAS-HIS SUCCESS data set biases as guidance, equivalent spectral position error (about 5-10% of MAS FWHM bandpass) was tested to investigate the cloud top pressure sensitivity to spectral error. Early indications are that this spectral error impact is less than the impact by other error sources (surface temperature estimate, atmospheric characterization, ice particle emissivity, etc.).

Visiting scientist Dr. Youri Plokhenko is processing the April 13 data set over Oklahoma to investigate MAS temperature/moisture retrieval sensitivity to surface emissivity. Using a physical retrieval algorithm to simultaneously determine atmospheric temperature/moisture and surface emissivity, he has found surface emissivity solutions ranging from .95 to .98 in the longwave infrared (8.6 to 14.2 micron) MAS channels and .91 to .98 in the shortwave infrared (3.0 to 5.3 micron) MAS channels. The effect of non-blackbody surface emissivity is demonstrated in Figure 9; the upper panel shows the 920 mb mixing ratio derived with a non-blackbody surface emissivity for part of the flight track on April 13 and the lower panel shows the same derived with a blackbody surface. Patterns of moisture and the strength of gradients are clearly affected. These preliminary results will be studied further.

PAPERS

Ackerman, S. A., C. C. Moeller, K. I. Strabala, L. E. Gumley, W. P. Menzel, 1997: Cloud Properties From MAS Observations During SUCCESS: Implications for MODIS, Spring Meeting of AGU, May 27-30, Conference on Subsonic Aircraft: Contrail and Cloud Effects Special Study (SUCCESS), Baltimore, Maryland.

Ackerman, S. A., 1997: Aircraft remote sensing of cloud microphysics. OSA Winter Topical Meetings. Optical Remote Sensing of the Atmosphere, February 10-14, Santa Fe New Mexico.

Elvidge, C.D., D. Pack, E. Prins, E. Kihn, K. Baugh, J. Kendall, 1997: Wildfire Detection with Meteorological Satellite Data: Results From New Mexico During June of 1996 Using GOES, AVHRR, and DMSP-OLS. Submitted to Remote Sensing Change Detection: Environmental Monitoring Methods and Applications, Ann Arbor Press.

King, M., S-C Tsay and S. A Ackerman, 1997: MODIS Airborne Simulator: Radiative properties of smoke and clouds during ARMCAS and SCAR-B, Third International Airborne Remote Sensing Conference and Exhibition, 7-10 July, Copenhagen, Denmark.

Menzel, W. P., D. P. Wylie, K. I. Strabala, and R. Frey, 1997: Eight years of global cirrus cloud statistics using HIRS. Technical Proceedings of the ninth International TOVS Study Conference.

Menzel, W.P., and E.M. Prins, 1996: Monitoring biomass burning with the new generation of geostationary satellites. In Biomass Burning and Global Change, Volume 1, edited by J.S. Levine, pp. 56-64, The MIT Press, Cambridge, MA.

Moeller, C. C., D. D. LaPorte, K. I. Strabala, P. Hajek, and W. P. Menzel, Spectral characterization of MODIS Airborne Simulator (MAS) LWIR bands and application to MODIS science data cloud products. Paper accepted for presentation at the Earth Observing Systems II Conference, SPIE, July 28-29, 1997.

Prins, E.M., and W.P. Menzel, 1996: Investigation of biomass burning and aerosol loading and transport utilizing geostationary satellite data. In Biomass Burning and Global Change, Volume 1, edited by J.S. Levine, pp. 65-72, The MIT Press, Cambridge, MA.

Prins, E.M., W.P. Menzel, D.E. Ward, 1997a: GOES-8 ABBA Diurnal Fire Monitoring during SCAR-B. In SCAR-B Proceedings, edited by V.W.J.H. Kirchhoff, pp 153-157, Transtec Editorial, Sao Paulo, Brazil.

Prins, E.M., W.P. Menzel, J.M. Feltz, and D.E. Ward, 1997b: An Overview of GOES-8 ABBA Results for SCAR-B: Diurnal Fire Activity and Regional Smoke Coverage.

Presented at the SCAR-B Special Session of the Spring AGU Meeting, Baltimore, MD, 27-30 May 1997.

Strabala, K. I., S. A. Ackerman, C. C. Moeller, L. E. Gumley, R. A. Frey, J. Y. Li and W. P. Menzel, 1996: Cloud Properties Determined from MODIS Airborne Simulator (MAS) SUCCESS Observations. Poster to be presented at the ERIM Third International Airborne Remote Sensing Conference and Exhibition to be held in Copenhagen, Denmark July 7-10, 1997.

MEETINGS

Dan LaPorte attended the Pre-environmental Review at Santa Barbara Remote Systems in California on 6-7 January.

Paul Menzel, Dan LaPorte and Chris Moeller attended the MODIS Thermal Infrared Calibration Team Meeting at the University of Miami on 9-10 January.

Elaine Prins attended the Conference on GIS and Remote Sensing Applications to Disaster Management in Greenbelt, MD on 14-15 January 1997 and presented a paper on the GOES-8 ABBA and future applications for early warning wildfire detection and monitoring in North America.

Steve Ackerman presented a paper at the Optical Remote Sensing of the Atmosphere Conference, February 10-14, Santa Fe New Mexico, titled “Aircraft remote sensing of cloud microphysics.”

Paul Menzel chaired the EOS PM platform ATBD review in Columbia, MD on 11 - 13 March 1997.

Elaine Prins attended the Langley DAAC UWG (Distributed Active Archive Center Users Working Group) Meeting in Hampton, VA on 13-14 March 1997.

Elaine Prins attended a meeting on 17 March at NASA GSFC to discuss the direction of the NASA MTPE sponsored interdisciplinary science study to characterize aerosol forcing over the Atlantic Basin associated with urban/sulfate, Saharan dust, and biomass burning aerosols and CIMSS participation in this effort.

Steve Ackerman attended a cloud mask discussion at GSFC with other MODIS team members in April.

Chris Moeller attended the PM-1 Spacecraft Maneuver meeting at GSFC on 6 May.

Chris Moeller, Kathy Strabala, Liam Gumley, Steve Ackerman, Dan LaPorte and Walter Wolf attended the MODIS Science Team meeting held 14-16 May in Greenbelt MD.

Steve Ackerman presented a poster at the AGU meeting in Baltimore, Maryland from 27-30 May titled “Cloud Properties From MAS Observations During SUCCESS: Implications for MODIS.”

Elaine Prins attended the SCAR-B science workshop and the AGU meeting in Baltimore, Maryland from 27-30 May and presented a paper at the AGU SCAR-B special session titled “An Overview of the GOES-8 ABBA Results for SCAR-B: Diurnal Fire Activity and Regional Smoke Coverage.”

Chris Moeller, Liam Gumley, and Dan LaPorte attended the MAS Instrument Summit meeting, 10-11 June at Ames Research Center, CA.

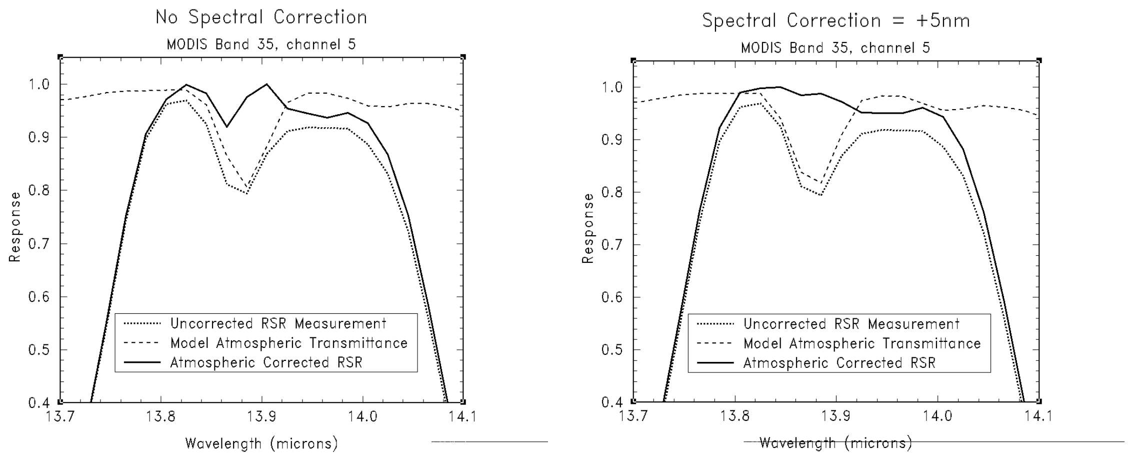


Figure 1. Blowup of MODIS atmospheric corrected RSR for band 35, channel 5. Applying a correction to the SpMA spectral reporting position creates a much better match of forward model generated transmittances with the observed spectral feature shape at 13.88 microns in the RSR measurements. The spectral feature in the resulting atmospherically corrected RSR is eliminated by the spectral correction.

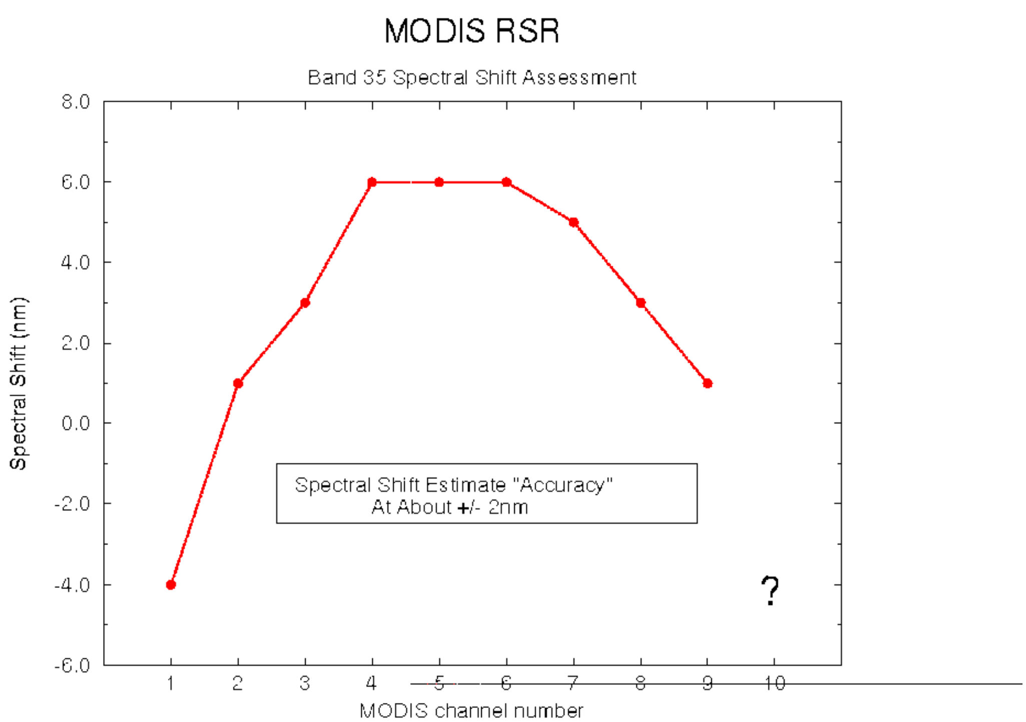


Figure 2. MODIS band 35 spectral correction for each channel. The estimated spectral correction is arrived at by matching spectral features of observed RSR data with that of forward model transmittances. "?" indicates that channel 10 yielded ambiguous results for spectral correction estimate and at this time is considered to be "out of family". Uncertainty of spectral correction considered to be about +/- 2nm.

Figure 3: The image below shows simulated MODIS Band 31 radiance data extracted from the most recent (March 1997) MODIS Level 1B file format. The image has been resampled to an isotropic Mercator projection. Latitude and longitude data for every 5th line and pixel is now stored in the MODIS 1km resolution HDF files, and this data was interpolated to the same resolution as the image data. Graphics are from IDL using CIMSS software .

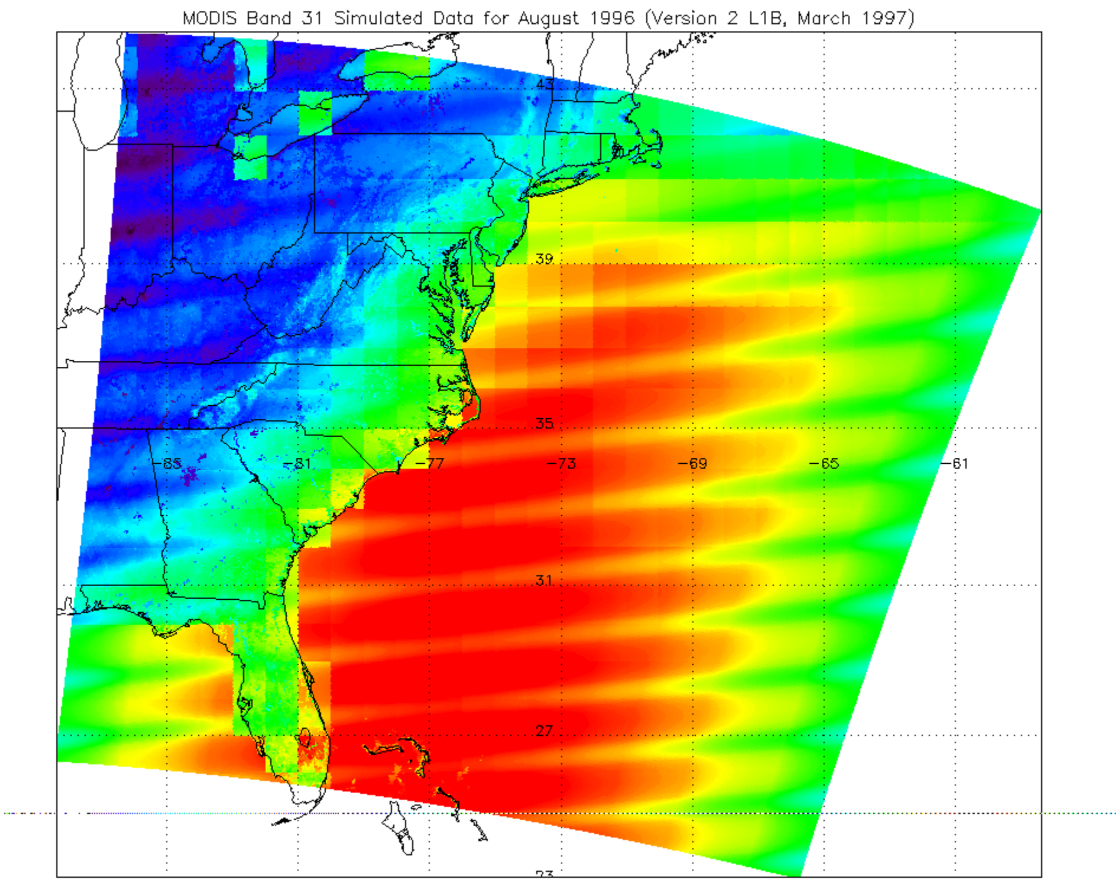
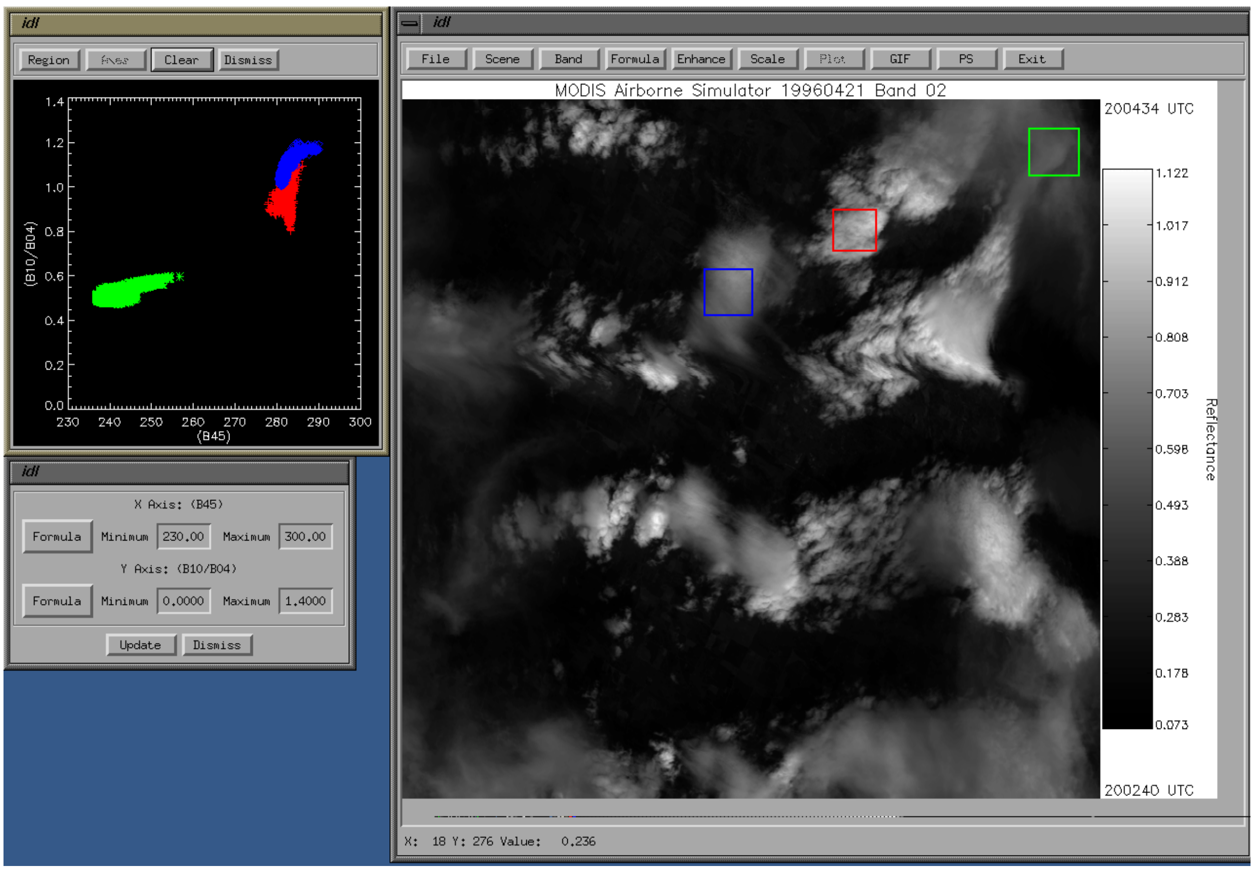


Figure 4: Shown below is a screen capture from a new MAS visualization program developed at CIMSS. The image shows MAS band 2 (0.65 microns), while the scatter plot shows a daytime cloud phase test. On the X axis is band 45 (11 micron) brightness temperature, and on the Y axis is band 10 (1.64 micron) reflection function divided by band 4 (0.74 micron) reflection function. The colored rectangles on the image correspond to the same colored points on the scatter plot. Data was read directly from a MAS HDF file. Similar functionality will be developed by CIMSS for visualizing MODIS data. This program was developed in IDL and has been run on SGI, Sun, IBM and Linux Unix platforms, and on Windows NT PC's (screen capture below is from an SGI).



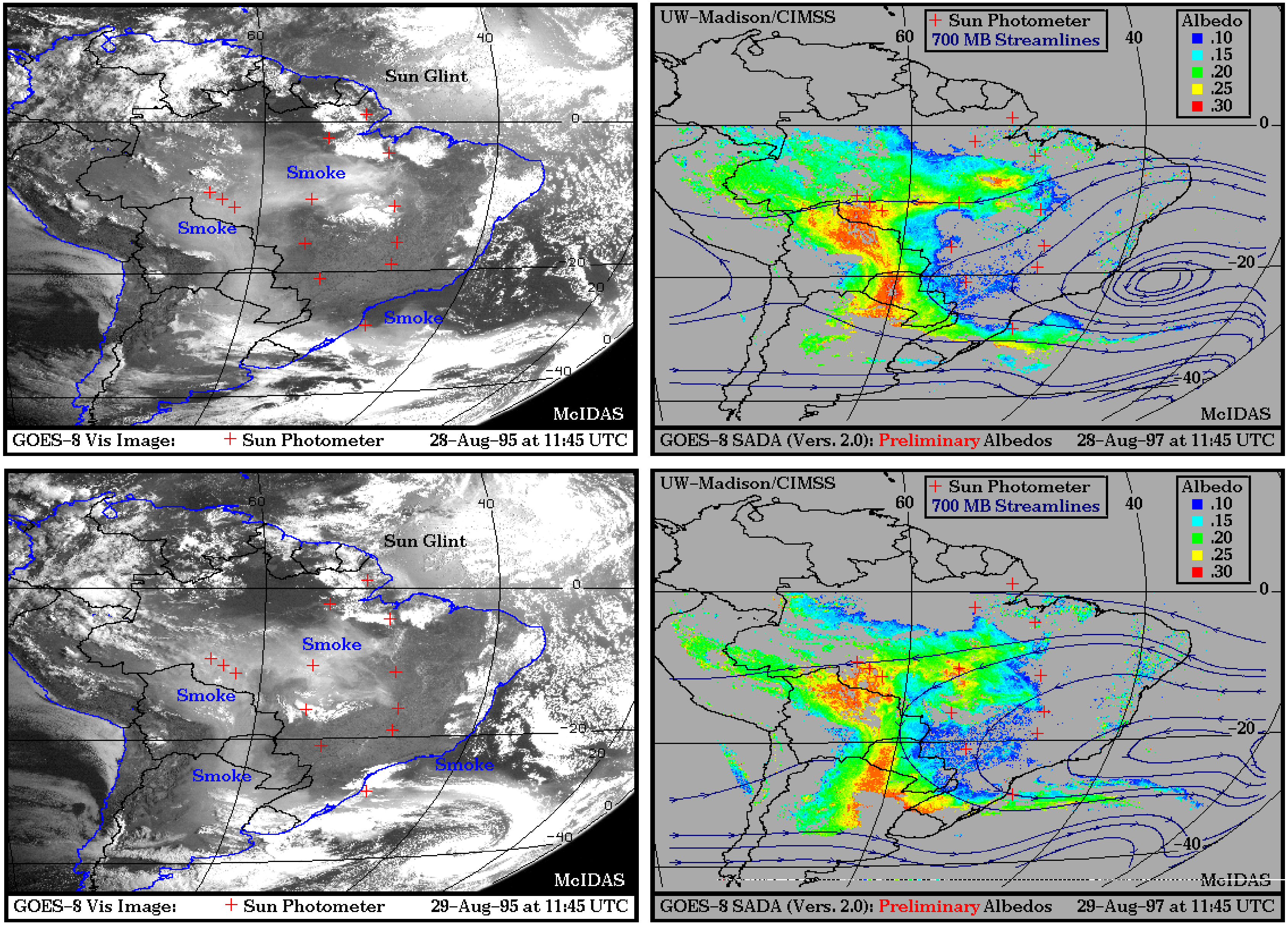


Figure 5. GOES-8 visible imagery and derived albedo product for 28 and 29 August 1995.

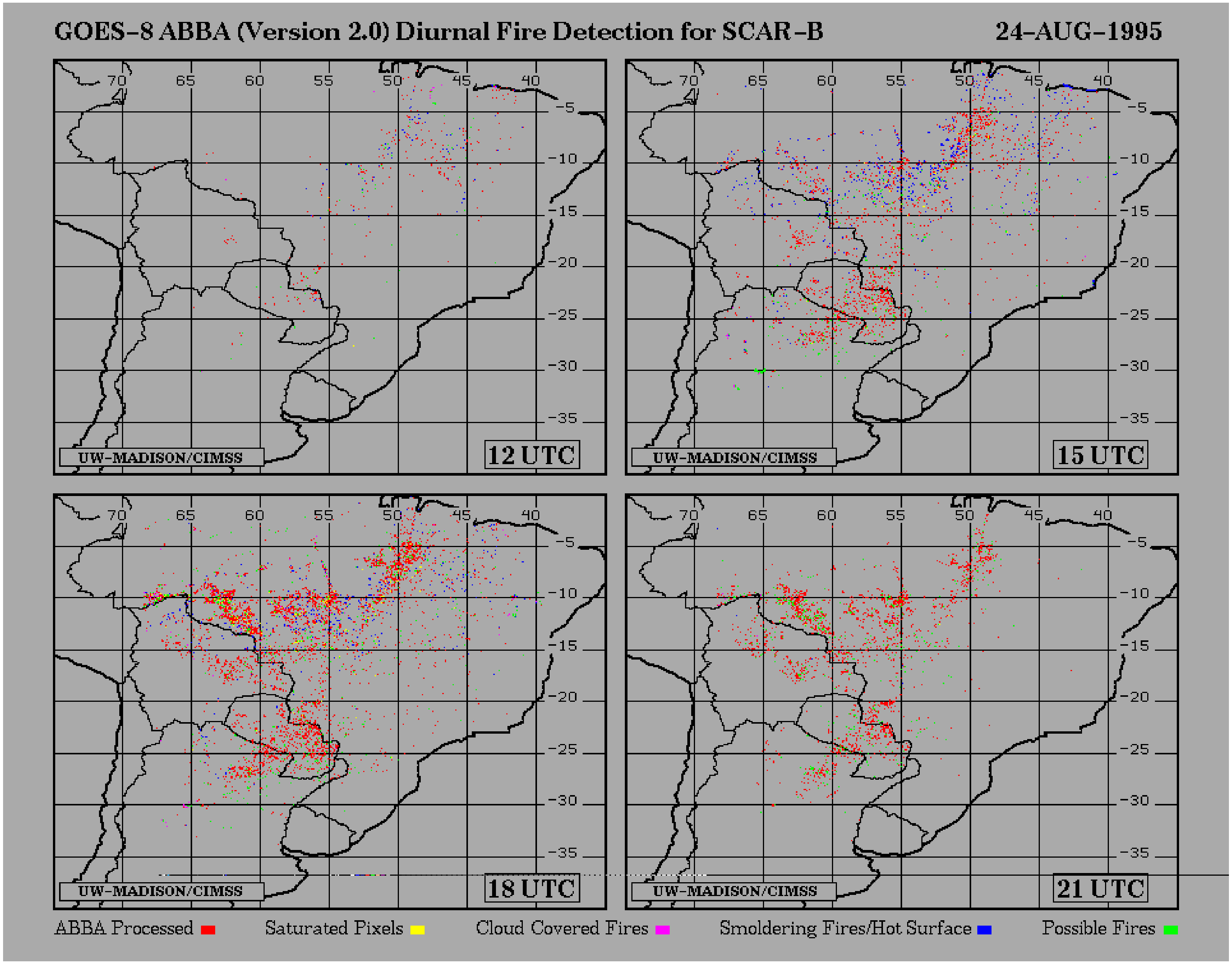
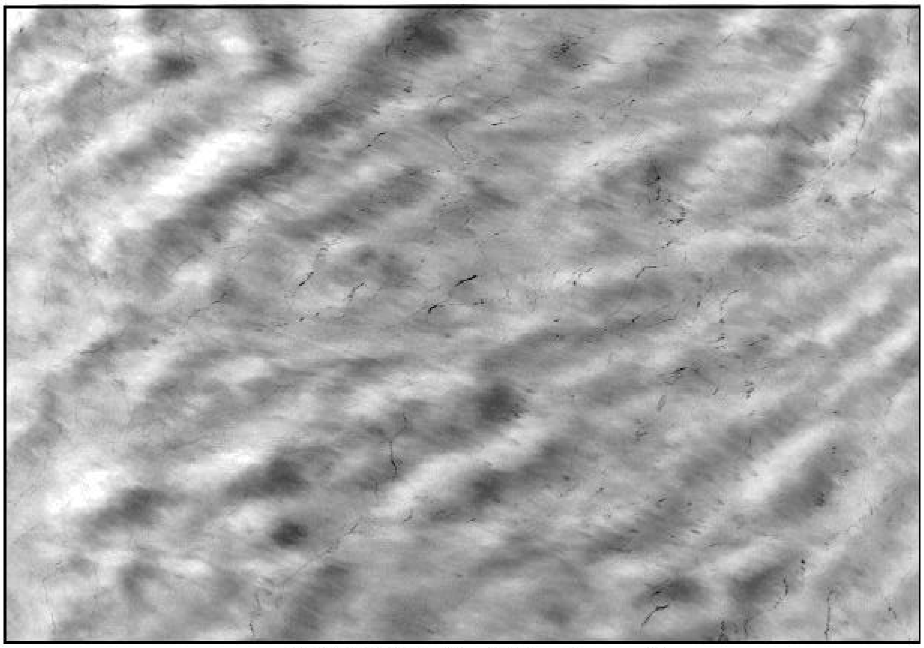


Figure 6. GOES-8 ABBA (version 2.0) diurnal results for 24 August 1995 at 1145, 1445, 1745, and 2045 UTC.



V I S I B L E (.56 microns)

T H E R M A L (11 microns)

Figure 7. MAS imagery over frozen Hudson Bay on 6 February 1997. Low transmissive clouds in the visible data (note cloud shadows) are almost invisible in the infrared (note prevalence of ice leads in the thermal data). MAS data from WINCE are being used to assess and improve MODIS cloud masking capability in difficult winter scene conditions such as is illustrated above.

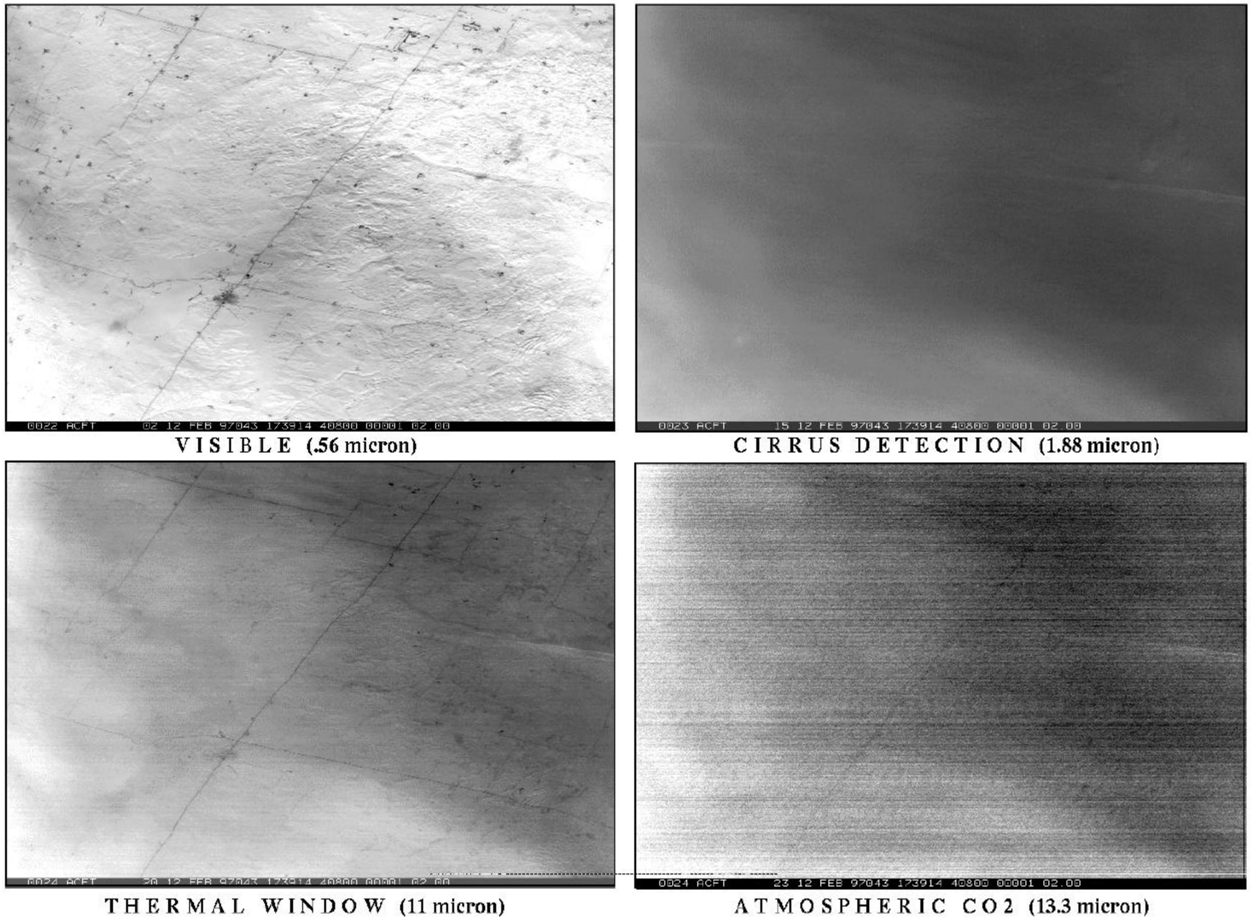
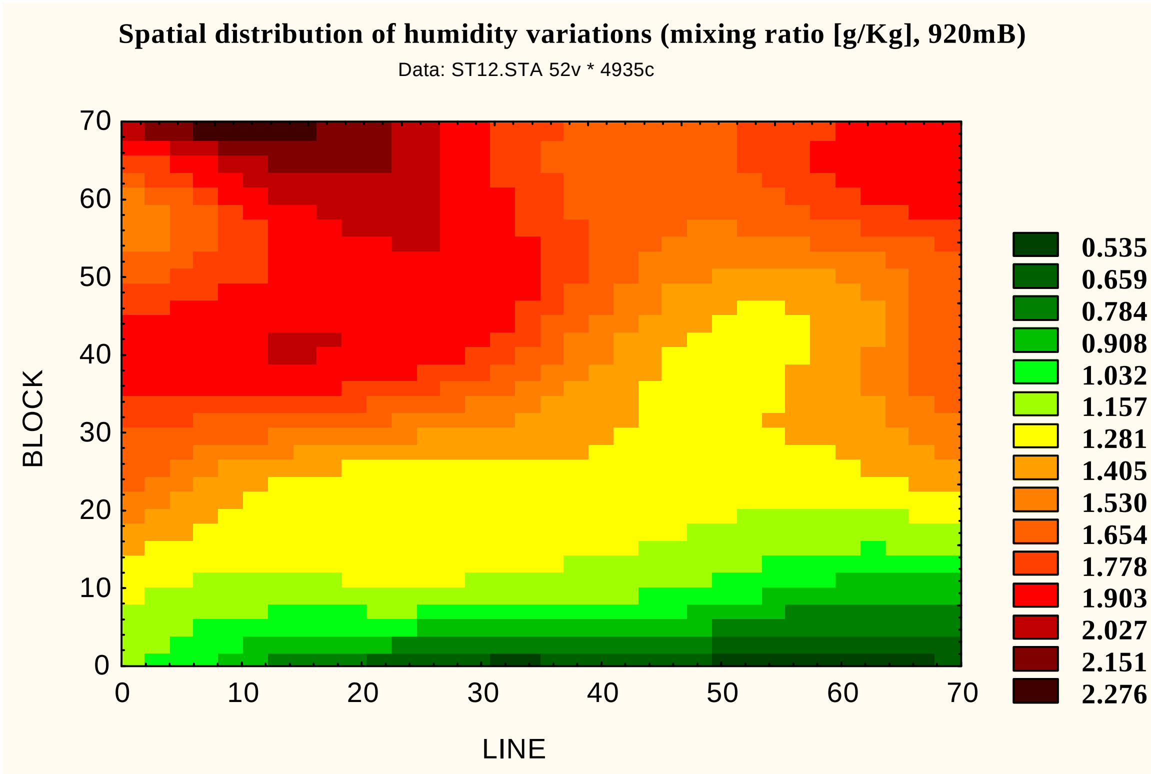


Figure 8. MAS imagery of thin cirrus scenes over snow-covered North Dakota on 12 February 1997. MAS (and MODIS) has a cirrus detection channel at 1.88 microns (MODIS 1.38 microns) which will be invaluable during daylight conditions for finding thin cirrus. At night, MAS (and MODIS) must rely on spectral tests using thermal bands such as CO2 sensitive channels to detect cirrus.



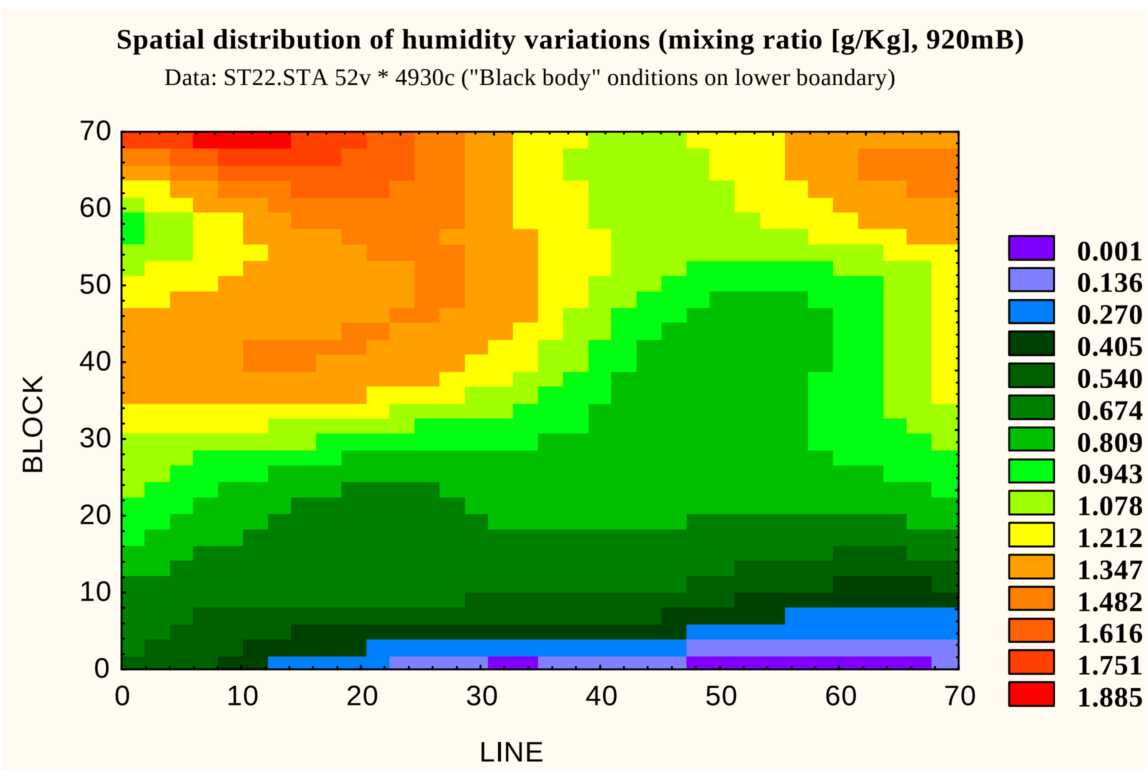


Figure 9. The effect of non-blackbody surface emissivity. Upper panel shows the 920 mb mixing ratio derived with a non-blackbody surface emissivity for part of the flight track on April 13; lower panel shows the same derived with a blackbody surface.